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DRAIN CLEANING AT BARRETT CHUTE GS AND MOUNTAIN CHUTE GS

Report No. 90-353-K

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ABSTRACT

The drainage system at Barrett Chute GS was improved by adding extra drains. In addition, the foundation drain, construction joint drains, gutters and pressure relief wells were cleaned using water jet equipment. Floor drains within the powerhouses of both Barrett Chute GS and Mountain Chute GS were also cleaned with a success rate of almost 100 percent.

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TABLE OF CONTENTS

		Page
1.0	**INTRODUCTION**	1
2.0	**BACKGROUND**	2
2.1	Barrett Chute GS - Drainage System	2
2.2	Barrett Chute GS - Inspection Tunnel Relief Wells	2
2.3	Barrett Chute GS - Construction Joint / Foundation Drains	2
2.4	Barrett Chute GS - Tailrace Pressure Relief Wells	3
2.5	Barrett Chute GS - Powerhouse Drains	3
2.6	Mountain Chute GS Powerhouse and Dam Drains	3
3.0	**OBJECTIVES**	3
4.0	**EQUIPMENT AND PROCEDURE**	4
4.1	Barrett Chute GS - Drilling Tailrace Outlet Holes	4
4.2	Barrett Chute GS - Sump Excavation	4
4.3	Barrett Chute GS - Drilling Access Holes.	5
4.4	Barrett Chute GS - Construction Joint / Foundation Drain Cleaning	5
4.5	Barrett Chute GS - Powerhouse Drain Cleaning	6
4.6	Mountain Chute GS - Powerhouse Drain Cleaning	6
4.7	Barrett Chute GS - Pressure Relief Well Cleaning	7
5.0	**DISCUSSION**	7
6.0	**RECOMMENDATIONS**	8
7.0	**CONCLUSION**	9
8.0	**ACKNOWLEDGEMENTS**	10
	APPENDIX A: JOB SAFETY ASSESSMENT	26
	APPENDIX B: WATER JETTING AND FLUSHING DETAILS	33
	APPENDIX C: DRAIN LOCATIONS AT BARRETT CHUTE GS AND MOUNTAIN CHUTE GS POWERHOUSES	44
	DISTRIBUTION	last page

LIST OF FIGURES

		Page
Figure 1:	Sectional View Of Drainage Between Chainages 4+94 and 5+24	11
Figure 2:	High Water Level In Tailrace Pond	12
Figure 3:	Low Water Level In Tailrace Pond	12
Figure 4:	Plan View Showing Location Of Drill Holes	13
Figure 5:	Flooding Due To Plugged Floor Drain	14
Figure 6:	Drilling Holes On Tailrace Slope	14
Figure 7:	Reaming Bit For Percussion Drill	15
Figure 8:	Reaming Bit and Drainage Holes	15
Figure 9:	Reaming Out Pilot Hole With Percussion Drill	16
Figure 10:	Excavation Of Drainage Sump	16
Figure 11:	Drainage Sump With Grate	17
Figure 12:	Drilling Holes To Intersect Box Drain	17
Figure 13:	Winkie Diamond Drill	18
Figure 14:	Drilling To Open Up Construction Joint Drains	18
Figure 15:	Hydro-Blaster Water Jetting Unit	19
Figure 16:	Pressure And Drainage Hoses In New Outlet Holes	19
Figure 17:	Murky Water From Box Drain Via Borehole During Water Jetting Operation	20
Figure 18:	Murky Water From Box Drain Via Borehole During Water Flushing Operation	20
Figure 19:	Air Compressor And Water Pump For Flushing	21
Figure 20:	Cleaning Floor Drains With Water Jetting Equipment	21
Figure 21:	Aluminum Plates At Bottom Of Construction Joint Drains	22
Figure 22:	Water Flowing Over Aluminum Plates Into Gutter	22

LIST OF TABLES

		Page
Table 1:	Borehole Details	23
Table 2:	Samples Obtained During Drain Cleaning	24

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DRAIN CLEANING AT BARRETT CHUTE GS AND MOUNTAIN CHUTE GS

1.0 INTRODUCTION

Water jetting techniques were used at Barrett Chute GS Main Dam to clean out the foundation drains, construction joint drains and pressure relief wells. Improvements in the drainage system were implemented by drilling two parallel drainage holes from the tailrace face to the inspection tunnel. Selected drains in the Barrett Chute GS and Mountain Chute GS powerhouses were also cleaned with a success rate of close to 100 percent. This work was conducted during a time frame extending from April 23, 1990 to June 29, 1990. The program was undertaken jointly by the Rock Sciences Section (Civil Research) and the Civil Maintenance Department with assistance from the Regional Staff at Barrett Chute GS and Mountain Chute GS.

2.0 BACKGROUND

2.1 Barrett Chute GS - Drainage System

The original 10 inch diameter outlet pipes, which drain water from the inspection chamber to the tailrace channel, exit the dam at a near horizontal grade and outlet below the water surface in the tailrace pond (Figure 1). During the summer, there is a head differential of approximately 11.5 feet between the bottom of the inspection chamber and the surface level of the pond. With this drainage system, it took approximately one and a half hours for the tracer dye to travel some 100 feet from the inspection chamber to the tailrace pond. The differential head level becomes approximately 5 feet when the sluiceways are opened to pass the spring freshet. Figure 2 shows the height of water in the tailrace pond early in the spring (March 28, 1990), while Figure 3 shows the water level after the spring runoff (April 25, 1990). During the spring runoff, the minimal head differential makes the original drainage system even more ineffective and could cause serious flooding in the inspection chamber.

In the past, regional staff have cleaned debris from the two original tailrace drains on a yearly basis. The cleaning process involved plugging the drains and raising the water level in the inspection chamber. Once the water level was raised, the plugs were removed. This in effect created a differential head pressure which caused materials to be flushed from the drains and into the tailrace pond.

2.2 Barrett Chute GS - Inspection Tunnel Relief Wells

A second problem that has occurred in the inspection chamber is the accumulation of orange - brown (rust-coloured) sediment which apparently comes from the pressure relief wells. This material is periodically removed by regional staff using brooms and shovels.

2.3 Barrett Chute GS - Construction Joint / Foundation Drains

Another concern was that many of the construction joint drains and presumably the foundation box drain contained debris which had the potential of restricting the flow of water from the bedrock foundation. Construction joint drains in the area of the diversion sluiceway (Figure 4) had been concreted over and had no known drainage pathway to the tailrace.

2.4 Barrett Chute GS - Tailrace Pressure Relief Wells

The orange-brown sediments have also accumulated in the houses which contain the pressure relief wells located at the base of the tailrace slope (Figures 2 and 3). The Dam Safety Section of the Civil Maintenance Department was concerned as to whether or not this material (or others) were commencing to plug up the pressure relief wells.

2.5 Barrett Chute GS - Powerhouse Drains

Over the years, many of the floor drains within the Barrett Chute GS powerhouse have become partially or fully blocked. Without maintenance, these plugged drains could have lead to flooding within the powerhouse.

2.6 Mountain Chute GS - Powerhouse and Dam Drains

Similar to the drains at the Barrett Chute GS powerhouse, floor drains within the Mountain Chute GS powerhouse and dam have also become partially or fully blocked. This situation led to flooding conditions within a section of the dam leading to the TS yard (Figure 5).

3.0 OBJECTIVES

1. Improve the drainage system within the Barrett Chute GS main dam.

2. Clean out the construction joint drains, foundation box drain and gutters within the inspection chamber of the Barrett Chute GS main dam.

3. Collect sediment samples from the Barrett Chute GS.

4. Improve drainage for construction joint drains in the diversion sluiceway section of Barrett Chute GS main dam.

5. Clean pressure relief wells located at the base of the tailrace slope at Barrett Chute GS main dam.

6. Clean out selected floor drains at Barrett Chute GS powerhouse.

7. Clean out selected floor drains at Mountain Chute GS powerhouse and dam.

8. Prepare a Job Safety Assessment (JSA) for the tasks indicated above prior to work commencement. For reference purposes, a copy of the JSA is provided in Appendix A.

4.0 EQUIPMENT AND PROCEDURE

4.1 Barrett Chute GS - Drilling Tailrace Outlet Holes

The three inch diameter pilot holes for the two new drainage holes (chainages 5 + 9.3 and 5 + 10.3) connecting the inspection chamber with the tailrace slope (Figure 1) were drilled using an Acker diamond drill, which is owned by the Rock Sciences Section (Figure 6). The two boreholes were drilled at an angle of approximately 2.4 degrees above the horizontal plane in the tailrace wall at an elevation of 589.25. The boreholes were drilled to intersect a shallow sump in the inspection chamber at an elevation of about 591.20 (six inches below the floor level at 591.7). The boreholes were then reamed out from three inch diameter holes to five inch diameter holes. The reaming shell (Figure 7) is designed to follow a pilot hole and is advanced using percussion drill equipment (Figure 8 and 9).

4.2 Barrett Chute GS - Sump Excavation

A shallow sump (nine inches deep) was excavated in the floor of the inspection chamber between chainages 5 + 09.8 and 5 + 11.3 to connect the new drainage holes with the floor gutter, which extends the full length of the inspection chamber. The sump was excavated by first drilling holes around the perimeter of the proposed sump (Figure 10) and then breaking out the concrete using a concrete breaker. A 90 degree notch was cut into the floor surrounding the sump (with the aid of a concrete saw) to enable placement of a steel grate to permit the safe passage of personnel (Figure 11). Since the completion of the project, regional staff have improved the sump by forming smooth concrete walls along the inside of the sump.

4.3 Barrett Chute GS - Drilling Access Holes

Five angled boreholes were drilled in the inspection chamber in an attempt to enable the self propelled water jet to enter the box drains. Boreholes 1 and 2 were drilled at an angle of 45 degrees, borehole 3 at 53 degrees, borehole 4 at 36.8 degrees, and borehole 5 was drilled at an angle of 9.9 degrees. A Winkie NX diamond drill owned by the Rock Science Section (Civil Research Department) was used to drill these holes (Figure 12 and 13). This drill was also used to open up six construction joint drains in the diversion sluiceway, which had no previous connection to the inspection chamber to permit drainage (Figure 14). The locations, angles and depths of all holes drilled are shown in Table 1.

4.4 Barrett Chute GS - Construction Joint / Foundation Drain Cleaning

The construction joint drains and foundation drains were largely cleaned using a water jet nozzle which contained one forward jet and three backward jets. The three backward facing jets propel the nozzle forward while the forward jet does the cutting/cleaning. Pressurized water is provided by a 10,000 psi Hydro-Blaster, which can also output a flow of approximately 12 U.S. gpm (Figure 15).

The unit was powered by a 600 volt, 100 amp GFI service, which was provided by the Regional staff. The Hydro-Blaster was placed on the road beneath the tailrace slope, and the hydraulic hose was advanced up one of the five inch diameter drainage holes and into the inspection chamber (Figure 16). A water pressure ranging from 5000 to 6000 psi was used for most of the water jetting operation (Figure 17). The flushing of water through the construction joint drains, foundation drains and boreholes (Figure 18) to check for inter-connections and wash out debris was accomplished by using a diaphragm pump (Figure 19). This pump has a rating of about 230 U.S. gpm and particle discharge size of three inches. A rental compressor was used to operate the pump (Figure 19). The second five inch diameter drainage hole was used to drain the water and debris from the inspection chamber to the tailrace (Figure 16).

The floor of the tunnel was cleaned using both the single orifice and fan water jets. Emphasis was placed on cleaning the gutters. Subsequent to this work, the construction joint drains and foundation drain were cleaned by using water jetting and water flushing procedures. A detailed description of this work is provided in Appendix B.

4.5 Barrett Chute GS - Powerhouse Drain Cleaning

The cleanout of drains (Figure 20) at the Barrett Chute GS powerhouse was accomplished using the Hydro Blaster (Figure 15) along with associated hydraulic hoses and nozzles. The Hydro Blaster was moved into the station and connected up with a 600 volt, 100 amp electrical service. The drains that were cleaned are highlighted by heavy dashed lines in Plans A, B, C, D and E in Appendix C. These plans are portions of the original construction drawings for the powerhouse and are referenced as such. The drains in the unloading bay (Plans A and B) contained large amounts of sand and gravel, which fell off vehicles while in the unloading bay. The water jetting nozzle became lodged in the drain shown at the top of Plan C and on Plan D. The exact location is shown by the "x" on Plan D. In an effort to free the nozzle and attached hydraulic hose, a four inch diameter borehole was drilled at this location, utilizing a rented industrial vacuum drill. The nozzle and hose were freed and the new drill hole was fitted with a drain cap and turned into a floor drain. The only drain, which was not totally cleaned is shown near the bottom of Plan E. The drain was not considered to be that significant so it was abandoned due to time constraints. With the exception of this drain, all of the other drains which were attempted were cleaned using water jetting and flushing procedures.

4.6 Mountain Chute GS - Powerhouse Drain Cleaning

The cleanout of drains at the Mountain Chute GS powerhouse was undertaken using the Hydro Blaster (Figure 15) along with associated hydraulic hoses and nozzles. The Hydro Blaster was moved into the station and connected up with a 600 volt, 100 amp electrical service. The drains that were cleaned are highlighted by heavy dashed lines in Plans F, G, H, I, J, K and L in Appendix C. These plans are portions of the original construction drawings for the powerhouse and are referenced as such. The drains in the loading bay area are shown in Plans F and on the right side of Plan G. A significant blockage was cleaned out of the pipe located between INV 676'-4" and INV 675'-3" on the right side of Plan G. Plan K shows the area of the entrance tunnel which was flooded due to a blockage in the floor drain (Figure 5). The drain shown in this plan is in reality located on the opposite side of the tunnel. Flooding of this area of the tunnel made it the most crucial area that required attention. The drains in the entrance way to the inspection chamber as shown in Plan L contained glass, sediments, twigs, sand and concrete. By using both water-jetting and flushing with fire hoses, a 100 percent cleaning success rate was obtained at Mountain Chute GS.

4.7 Barrett Chute GS - Pressure Relief Well Cleaning

The cleanout of the pressure relief wells at the base of the tailrace slope at Barrett Chute GS was accomplished using the Hydro-Blaster unit along with associated hydraulic hoses and nozzles. All of the relief wells were cleaned to their maximum drilled depths. The locations and depths of these wells are provided in a report prepared by the Civil Engineering and Architecture Department (Madawaska River: Barrett Chute GS - Main Dam: Geotechnical Evaluation of Foundation Conditions - 1989: Report No. 89518).

5.0 DISCUSSION

The two new tailrace drainage holes provide the following advantages: 1) Since they provide a direct pathway from the inspection chamber to the tailrace, the possibility of flooding within the inspection chamber is greatly reduced. 2) The boreholes also provide access for hydraulic hoses from the outside to simplify the cleaning of the construction joint drains and foundation box drain. 3) The boreholes can also be used to remove water and sediment from the inspection chamber without dumping them into the two original drains at chainages 4 + 94.5 and 5 + 23.5. 4) Installation of a submersible pump in the construction joint at chainage 5 + 08 will allow a means of continuously flushing the drainage system (ie construction joint drains and box drains). This will hopefully keep the water flowing quickly enough to minimize sedimentation and iron oxide formation. The pump can also provide a means of measuring the flow of water through the drainage system to the tailrace and could be monitored by the on-site data logging system. 5) In the event of a pump failure (ie power outage), the flow will revert to its original pattern and exit through the existing drains and the new outlet drains if necessary.

An attempt to gain access to the box drain by drilling holes at angles of approximately 45 degrees has been successful even though the box drain was a difficult target to hit. Unlike most box drains the box drain at Barrett Chute GS is relatively small. Similar to the construction joint drains, its dimensions are six inches by six inches. The most difficult portion of the drilling program was coring through the wood of the box drains. The advantage of using angled holes into the box drain is that it allows the entry of the self-propelled water jet into the box drain in a known direction. They also provide access for flushing and act as pressure relief wells.

One of the problems with the design of the construction joint drainage system is that the debris in the inspection chamber gutters can fall into the construction joint drains and then into the foundation drains. While the drain cleaning program was underway, a significant amount of drill cuttings was removed from the drains. These cuttings made there way into the foundation drain during various drilling programs, which have previously been carried out in the inspection chamber. As a means to keeping materials from falling into the construction joint drains and into the foundation drain, aluminum plates were fabricated and installed in such a way that water could only drain from the construction joint drain into the gutter and not vice versa (Figures 21 and 22). These units were installed on all construction joint drains prior to the commencement of our drilling program in the inspection chamber.

The waterjet nozzle became lodged in one of the drain pipes at Mountain Chute GS due to a constriction in a connector sleeve, which joins two pipes together. Had the joint been designed in such a manner that the inside diameter of the connecting pipes and the sleeve were the same, the lodgement of the nozzle most likely would not have occurred. These constrictions could also act as sediment traps and contribute to the plugging of the drains.

In an effort to keep the drains at both the Barrett Chute GS and Mountain Chute GS powerhouses open and clean, a regular flushing program should be initiated. It is suggested that flushing be undertaken twice yearly (spring and fall).

Some of the samples that were collected during the drain cleaning program at Barrett Chute GS Main Dam will be chemically analyzed in 1991. These results will be presented in a separate report.

6.0 RECOMMENDATIONS

1. Attachments are required to enable cutting through the wood of box drains to gain entrance into the drain.

2. The acquisition of larger pistons for the Hydro-Blaster would enable higher flow rates (ie 35 gpm at 3500 psi) and improve the cleaning operation.

3. The installation of aluminum plates at the bottom of construction joint drains should be installed in all stations to prevent gutter debris (ie drill cuttings) from entering the drainage system. The use of screens in front of the construction joint drains would prevent debris from being dropped into the drain.

4. A water jet propulsion system should be assembled to enable a closed circuit television camera or specialized cutting nozzles to be pushed through long drains.

5. The floor drains in the powerhouses at both Barrett Chute GS and Mountain Chute GS should be flushed regularly (ie spring and fall) to prevent them from plugging up.

6. Future drain designs in power stations should include connectors which do not reduce the inside diameter of the drain pipe.

7.0 CONCLUSION

The drainage system at the Barrett Chute GS main dam was improved by drilling two parallel holes. Water jetting techniques were used to clean out the foundation drains, construction joint drains and pressure relief wells at Barrett Chute GS. In addition, selected drains in the Barrett Chute GS and Mountain Chute GS powerhouses were cleaned with a success rate of almost 100 percent.

8.0 ACKNOWLEDGEMENTS

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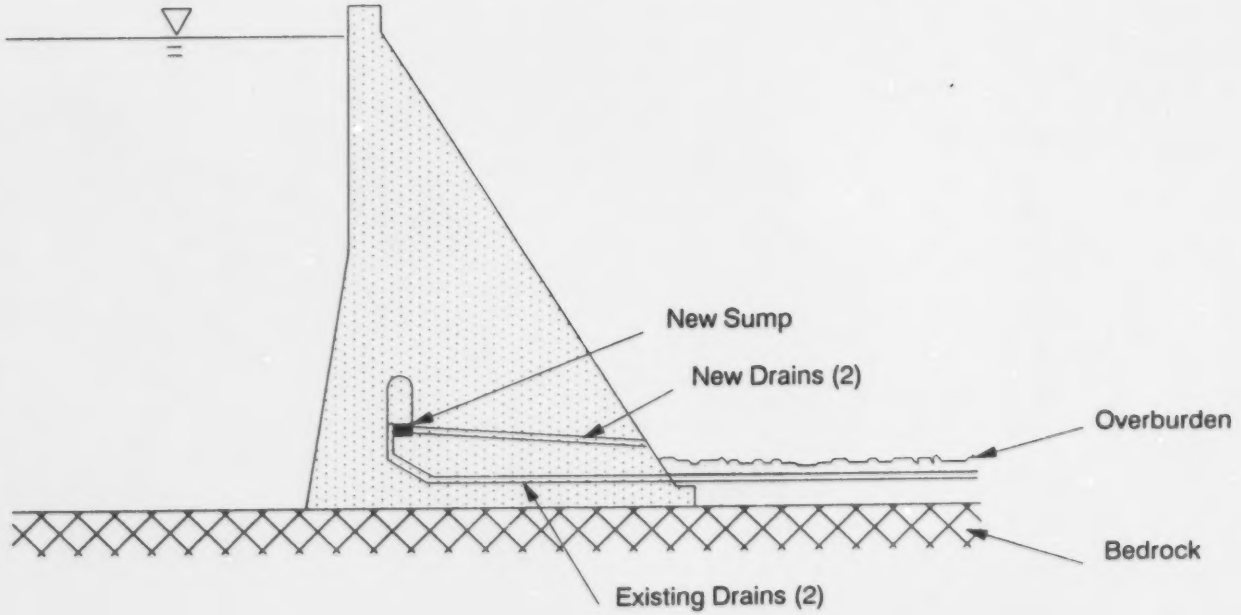


Not To Scale

Figure 1

Sectional View Of Drainage Between Chainages 4+94 and 5+24

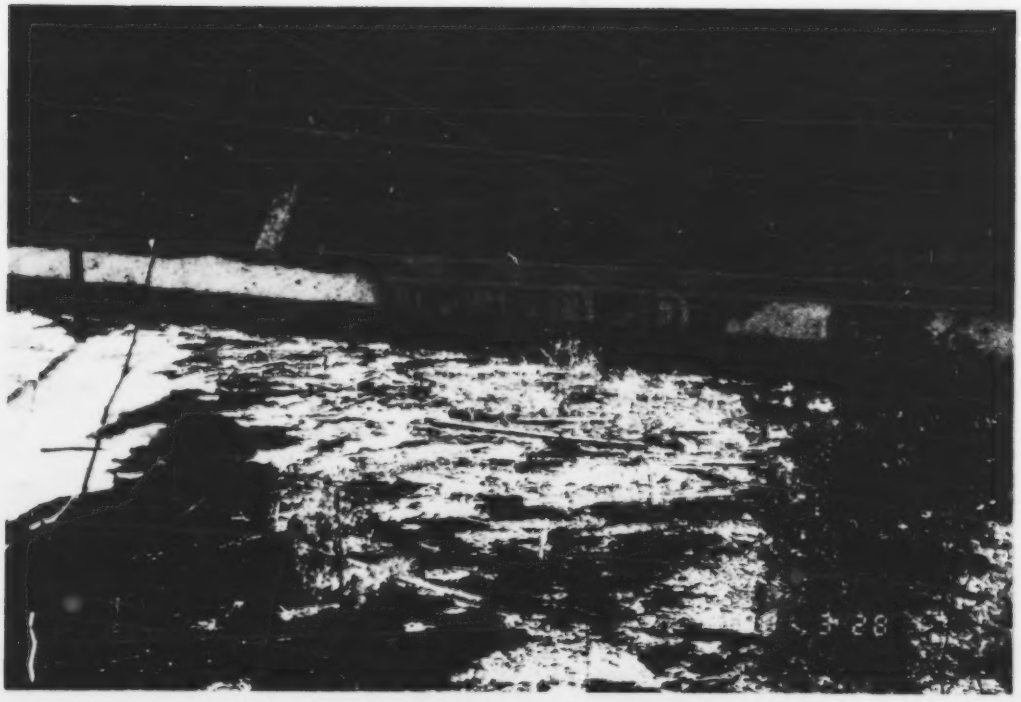


Figure 2: High Water Level In Tailrace Pond

Figure 3: Low Water Level In Tailrace Pond

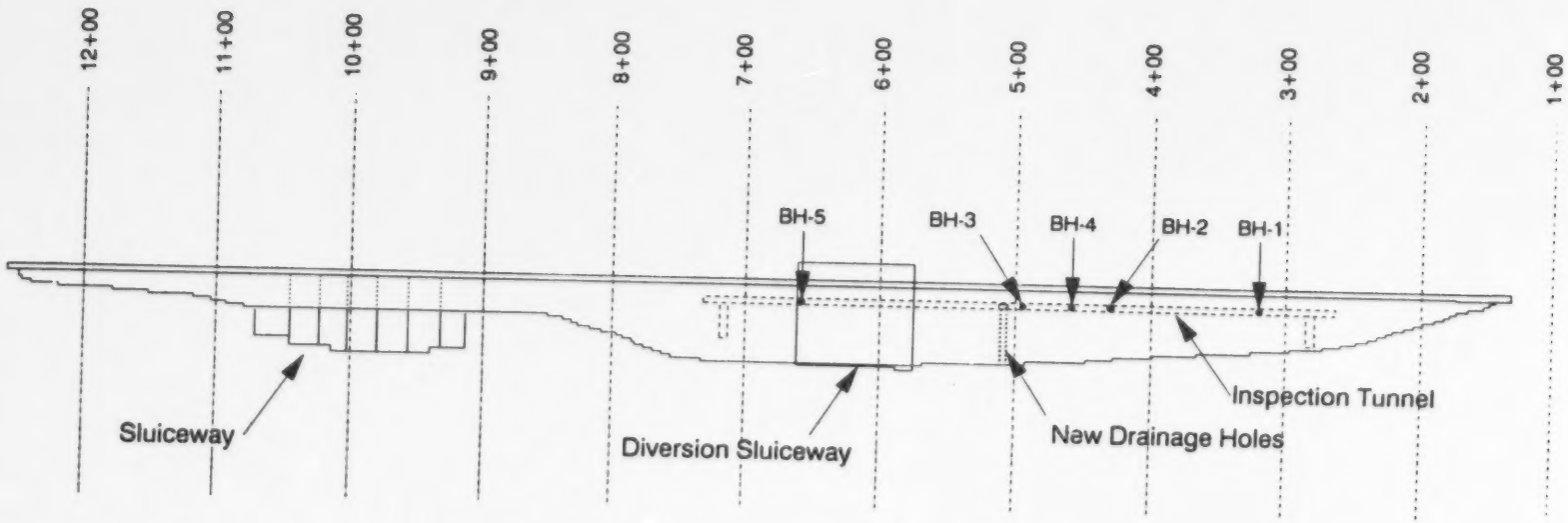


Figure 4

Plan View Showing Location Of Drill Holes

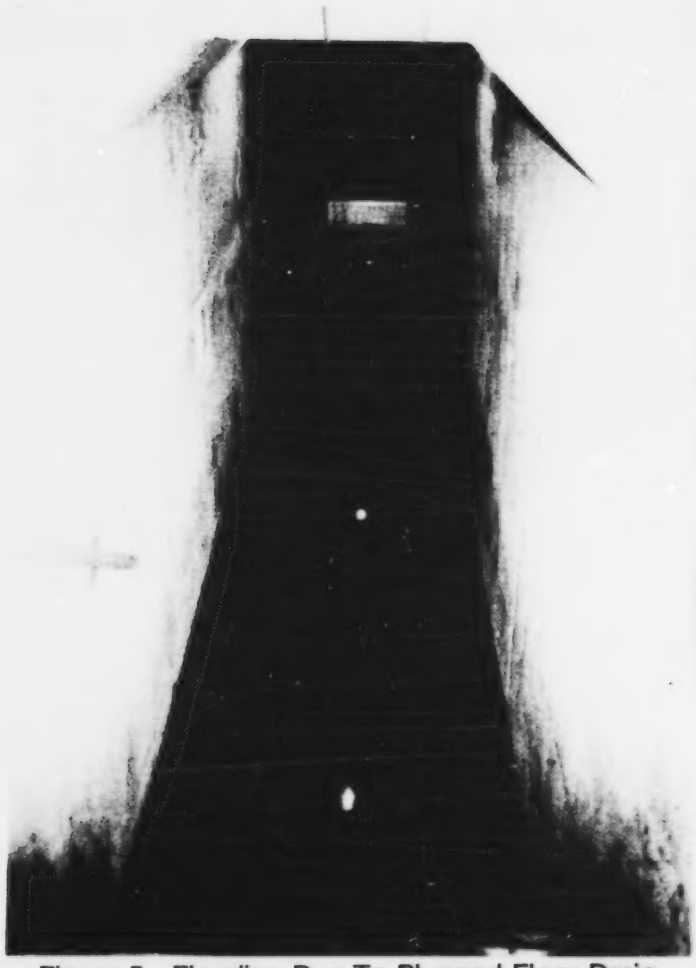


Figure 5: Flooding Due To Plugged Floor Drain

Figure 6: Drilling Holes On Tailrace Slope

Figure 7: Reaming Bit For Percussion Drill

Figure 8: Reaming Bit and Drainage Holes

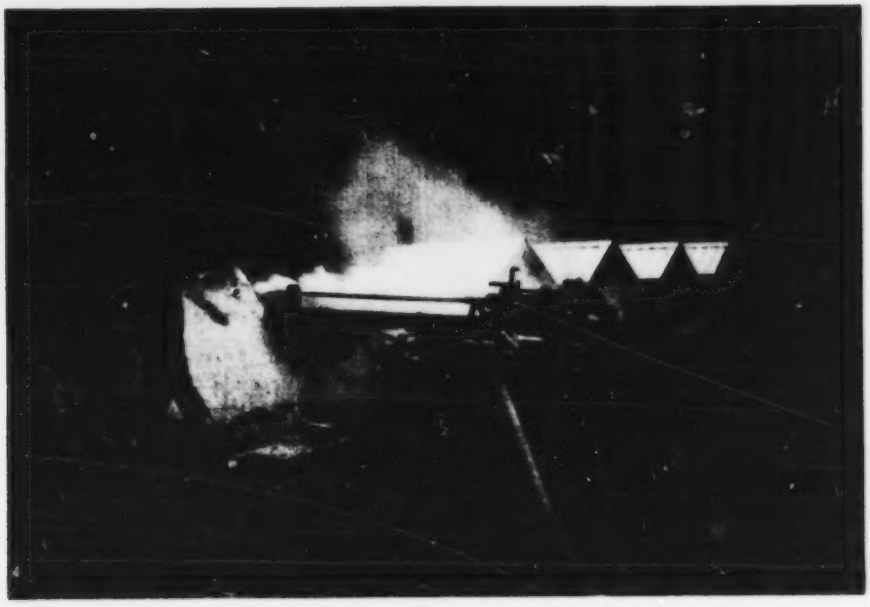


Figure 9: Reaming Out Pilot Hole With Percussion Drill

Figure 10: Excavation Of Drainage Sump

Figure 11: Drainage Sump With Grate

Figure 12: Drilling Holes To Intersect Box Drain

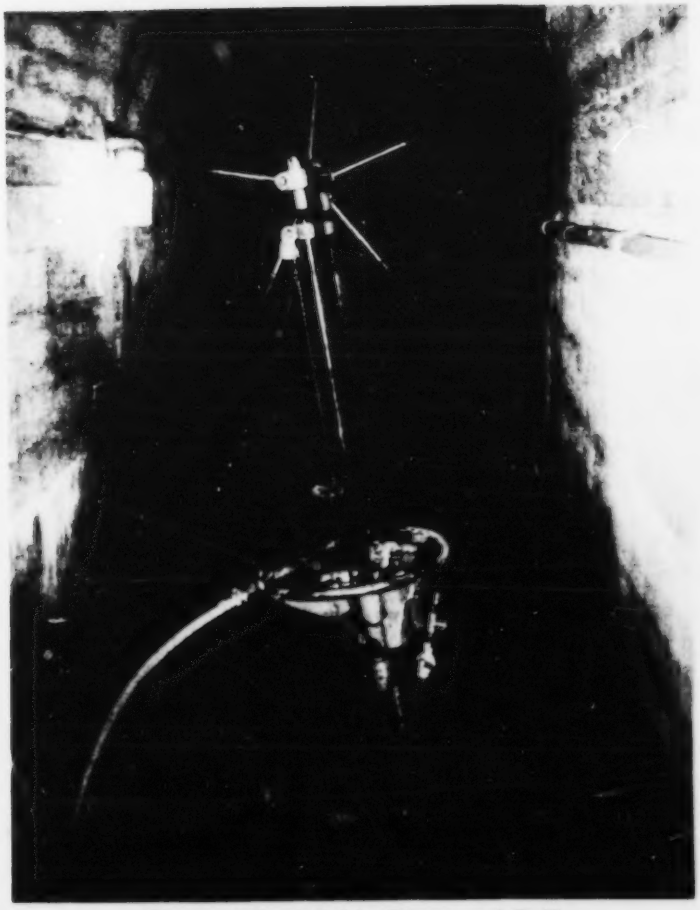


Figure 13: Winkie Diamond Drill

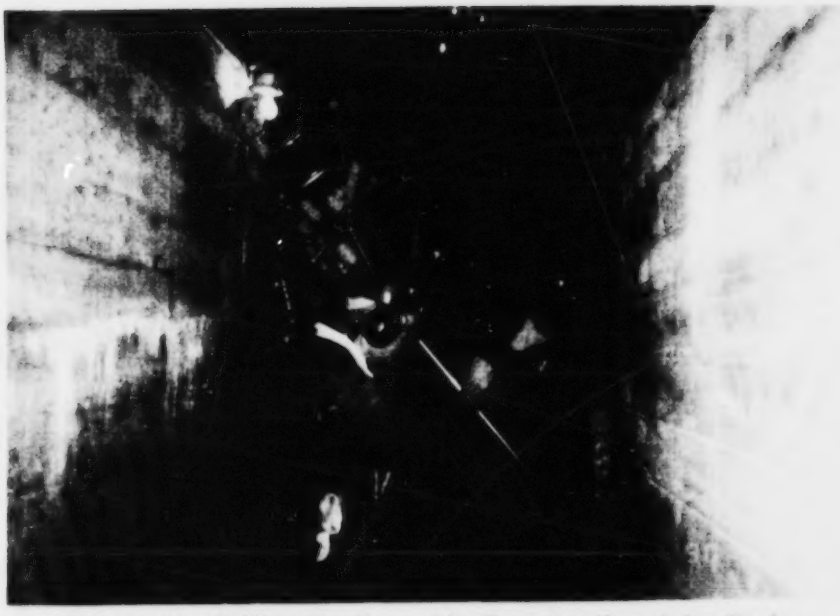


Figure 14: Drilling To Open Up Construction Joint Drains

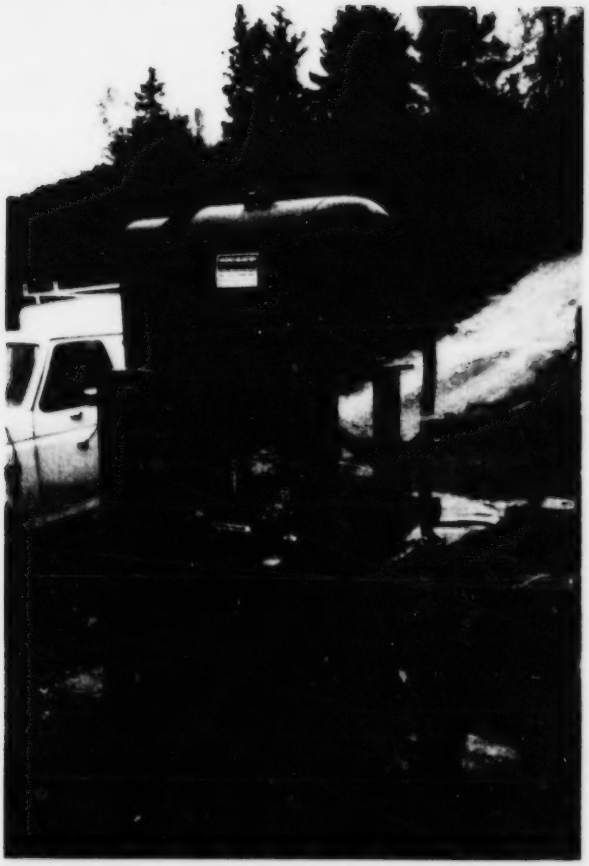


Figure 15: Hydro-Blaster Water Jetting Unit

Figure 16: Pressure And Drainage Hoses In New Outlet Holes

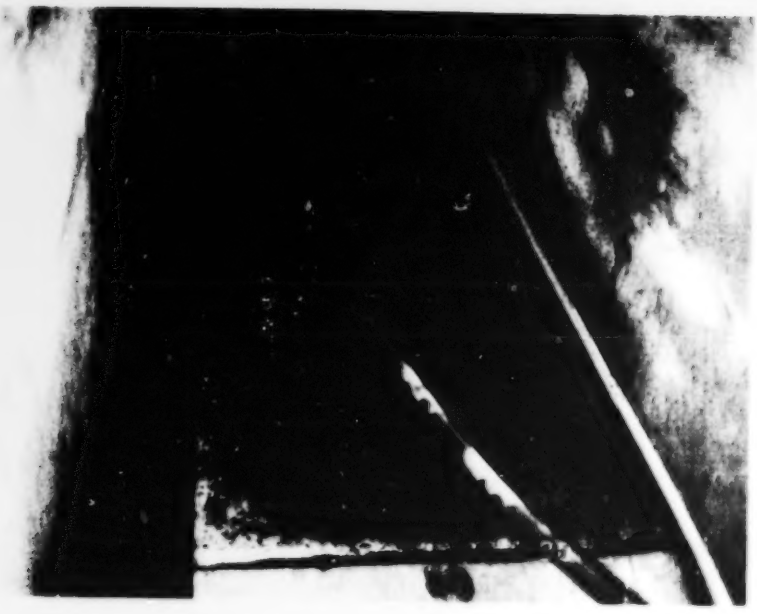


Figure 17: Murky Water From Box Drain Via Borehole During Water Jetting Operation

Figure 18: Murky Water From Box Drain Via Borehole During Water Flushing Operation

Figure 19: Air Compressor And Water Pump For Flushing

Figure 20: Cleaning Floor Drains With Water Jetting Equipment

Figure 21: Aluminum Plates At Bottom Of Construction Joint Drains

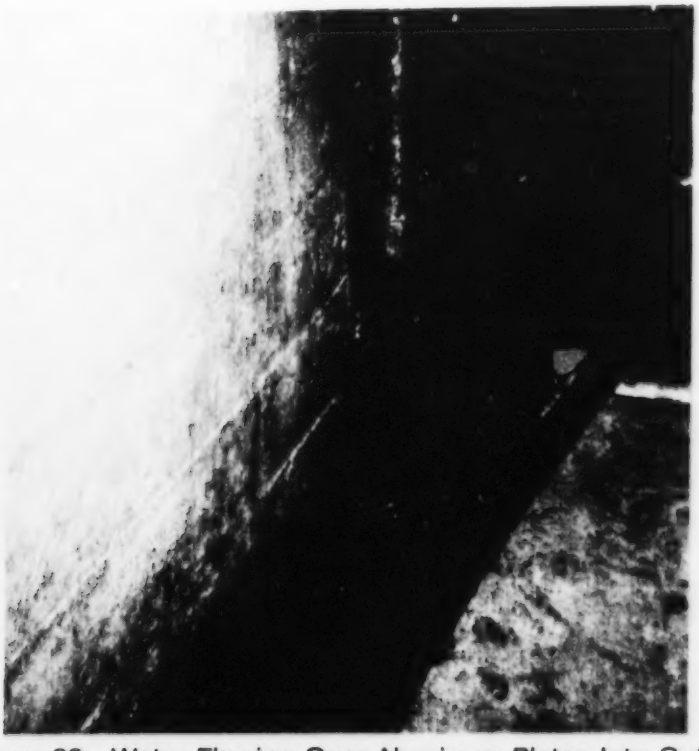


Figure 22: Water Flowing Over Aluminum Plates Into Gutter

TABLE 1: BOREHOLE DETAILS			
Borehole Location (Ft)	Angle From Horizontal (Degrees)	Depth Of Borehole (Ft)	Comments
5 + 09.3	+2.4 West	44	Outlet Drain
5 + 10.3	+2.4 West	44	Outlet Drain
3 + 19.4	-45 South	13.5	Intersect Box drain
4 + 30.2	-45 North	17.3	Intersect Box drain
4 + 58.3	-36.8 North	18.7	Intersect Box drain
4 + 94.5	-53 South	23.3	Intersect Box drain
6 + 59.3	-9.9 West	10.6	Intersect Box drain
5 + 76	-45 West	2.0	Intersect CJD 11
5 + 90.5	-45 West	1.5	Intersect CJD 12
6 + 10.5	-45 West	1.5	Intersect CJD 13
6 + 25	-45 West	2.0	Intersect CJD 14
6 + 45.5	-45 West	2.0	Intersect CJD 15
6 + 59.8	-45 West	2.0	Intersect CJD 16

TABLE 2: SAMPLES OBTAINED DURING DRAIN CLEANING			
Sample Number	Date Samples	Location	Comment
1	May 9, 1990	BH-1	Borehole Sample
2	May 9, 1990	BH-2	Borehole Sample
3	May 9, 1990	BH-2	Borehole Sample
4	May 9, 1990	BH-2	Borehole Sample after Washing
5	May 9, 1990	CJD (4 + 78)	Gutter Sample After Jetting
6	May 9, 1990	CJD (5 + 08)	CJD Sample
7	May 10, 1990	CJD (3 + 00)	CJD Sample
8	May 10, 1990	BH-1	Gutter Sample After Jetting
9	May 10, 1990	CJD (3+28.5)	Gutter Sample After Jetting
10	May 10, 1990	CJD (3 + 58.5)	Gutter Sample After Jetting
11	May 10, 1990	CJD (3 + 88.5)	Gutter Sample After Jetting
12	May 10, 1990	CJD (4 + 18.5)	Gutter Sample After Jetting
13	May 10, 1990	CJD (4 + 48)	Gutter Sample After Jetting
14	May 10, 1990	CJD (4 + 78.5)	Gutter Sample After Jetting
15	May 10, 1990	CJD (5 + 08)	Gutter Sample After Jetting
16	May 10, 1990	CJD (5 + 38)	Gutter Sample After Jetting
17	May 10, 1990	CJD (5 + 75.5)	Gutter Sample After Jetting
18	May 10, 1990	CJD (5 + 91)	Gutter Sample After Jetting
19	May 10, 1990	CJD (6 + 10.9)	Gutter Sample After Jetting
20	May 10, 1990	CJD (6 + 25.9)	Gutter Sample After Jetting
21	May 10, 1990	CJD (6 + 45.9)	Gutter Sample After Jetting
22	May 10, 1990	CJD (6 + 60.9)	Gutter Sample After Jetting

TABLE 2: SAMPLES OBTAINED DURING DRAIN CLEANING (CONT'D)			
Sample Number	Date Samples	Location	Comment
23	May 10, 1990	CJD (6 + 90.9)	CJD Sample
24	May 15, 1990	CJD (5 + 08)	CJD Sample
25	May 15, 1990	CJD (5 + 08)	CJD Sample
26	May 15, 1990	CJD (4 + 78.5)	CJD Sample
27	May 16, 1990	CJD (4 + 50)	CJD Sample
28	May 17, 1990	BH-2	Borehole Sample
29	May 23, 1990	BH-4	Borehole Sample
30	May 24, 1990	CJD (5 + 38)	CJD Sample
31	May 24, 1990	CJD (5 + 38)	CJD Sample
32	May 25, 1990	BH-4	Grout Sample
33	May 25, 1990	BH-4	Gutter Sample
34	May 28, 1990	BH-4	Gutter Sample
35	May 29, 1990	BH-3	Borehole Sample
36	May 29, 1990	CJD (4 + 78)	Gutter Sample

APPENDIX A:
JOB SAFETY ASSESSMENT

HAZARD IDENTIFICATION GUIDE

JOB PLANNING STEPS

1. TASK – describe the job.
2. JOB STEPS – break the job down into manageable steps.
3. HAZARDS – for each step identify the hazards.
4. BARRIERS – select barriers to eliminate, control or minimize the hazards.
5. ASSESS – review the job plan to ensure the methods of reducing the risk are effective and practical.
6. TAIL BOARD CONFERENCE – discuss job plan with crew daily.
7. CHANGE – monitor the work for change. If encountered implement counter change and discuss with crew.

1. **TASK – describe the job.**

Assess the condition of the foundation drains. Flush and water jet the existing drainage system. Modify the foundation drainage system to improve performance and reduce maintenance requirements.

2. **JOB STEPS – break the job down into manageable steps.**

1	Electrical Hook ups	600 VAC to both Portals 220 VAC to Pump location	11	Install culvert under road
2	Backhoe to excavate drill pad			
3	Mobilize			
4	Drill and break out concrete in inspection tunnel - pipes, sump, pump pocket			
5	Drill holes from outside			
6	Flush and/or water jet CJD and inspect with TV camera			
7	Drill 45 degree holes to intersect box drain at CJD as required			
8	Water jetting of the box drain			
9	Inspection of work with TV camera			
10	Pump installation			

HAZARDS – for each step identify the hazards.

ENERGIES		MANAGED SYSTEM
gravity	G	• atmosphere **ENVIRONMENT** - toxic/unsafe
electrical	E	**PEOPLE**
mechanical	M	• general public • other work groups
body mechanics	B/M	• knowledge/qualified
noise	N	**PROCEDURES** **HARDWARE**
chemical	C	• permits - confined spaces - work protection • adequate capacity
heat/light	H/L	• approved work practices • condition
pressurized fluids	P/F	• procedures • suitable • weather • ground conditions
		• severe grounding hazard • proximity to live equipment

BARRIERS – select barriers to eliminate, control or minimize the hazards.

job step	energy	hazards	barriers
1	E	Electrical hookups	Conducted by Regional Electricians
		4.6 kV overhead cables along road	Observe safe distance
			Signs
2	E	Buried service, overhead lines	Region to locate and inform contractor
3	B/M	Equipment handling	Use Hyab truck and regional riggers Proper lifting techniques
	G	Equipment falling	Secure equipment in place
4	G	Moving equipment down stairs	Use skids and winch Keep area clear below
		Concrete falling when broken off wall	Break into small pieces, stand back during breaking
	E	Electric shock	Use GFI Use DC battery
	M	Winch, drill	Keep fingers clear, use gloves Operator incharge
	B/M	Lifting; drill steel, broken concrete	Use helpers and proper lifting techniques, winch up stairs
	N	Drilling	Hearing protection attached to hard hats.
	C	Hydraulic oil spill from rock breaker membrane rupture	3m sorbent pillows
		Drilling fines	Drains will be covered, all drill fines will be removed
	P/F	Rupture of membrane or hose	High strength hose and couplings pressure gauge, remote operation

5. ASSESS – review the job plan to ensure the methods of reducing the risk are effective and practical.

BARRIERS – select barriers to eliminate, control or minimize the hazards.

job step	energy	hazards	barriers
5	G	Moving drill steel	Secure in racks Tie off as required
	B/M	Personal lifting injuries	Use two people (experienced)
	N	Noise	Hearing defenders
	C	Fuel for compressor	Fill up daily with red plastic cans
			Store fuel at station (Regional tanks)
	H/L	Hot bits	Use gloves
	P/F	Hose blow out	Hose snares at couplings stand back from compressor
6	G	Water filled hose	Tie off to wall
	E		GFI
	M	Moving parts	Guards on all moving parts
	B/M	Operator fatigue during water jetting	Work 10-15 minute shifts
	N	Loud noise when jet operating	Hearing protection, signs at tunnel portals warning visitors
	H/L	Power failure	All personnel to carry flashlights
	P/F	High pressure water jetting	Follow "Recommended Practies for the Use of manually operated high pressure water jetting equipment" manual
7		Covered by Step 5	

5. ASSESS – review the job plan to ensure the methods of reducing the risk are effective and practical.

BARRIERS – select barriers to eliminate, control or minimize the hazards.

job step	energy	hazards	barriers
8	E	Electric Shock	Use 600 VAC GFI Mount Junction Box high on pole, keep
			locked off when not in use
	M	Burst hose	Follow "Recommended Practices . . ." Inspect hoses, use high safety factor
			burst pressure on hose
		Pieces break in power unit	Keep unit outside and keep personnel away during operation
	N	Loud noise	Hearing protection
	H/L	Fire in electric motors	Turn off power Use ABS fire extinguisher
	P/F	See Step 6	
9	E	Electric Shock	Use GFI Use DC lighting under water
	B/M	Lifting and lowering TV camera	Use 2 people
10	G	Carrying pump down stairs	Use skids and winch
	E	Pump hookup	Use electricians, GFI waterproof junction box
	M	Piping	Use plastic pipe anchored to concrete
		Moving parts	Install guard over moving parts
11	E	Overhead wires	Notify contractor Mark with flags and signs
		buried service next to dam	Turn power for heat cables off
	H/L	Frost heave	Install insulation over pipes

5 ASSESS – review the job plan to ensure the methods of reducing the risk are effective and practical.

TAIL BOARD CONFERENCE – discuss job plan with crew daily.

crew supervisor	crew	

date	steps discussed	date	steps discussed

CHANGE – monitor the work for change. If encountered implement counter change and discuss with crew.

date	change	counter change

anagement supervisor's review and comments

JSA prepared and discussed at a meeting February 20, 1990

CRD, CMD, Renfrew District Mech. and Elec.

signature Paul Tuth date Feb 28/90

APPENDIX B:
WATER JETTING AND FLUSHING DETAILS

WATER JETTING AND FLUSHING DETAILS			
Date	CJD/BH	Chainage	Comments
May 9	CJD-2	3 + 100	- No water from drain during jetting - Water level in CJD-3 fluctuated between 1 and 2 feet from top - Nozzle advanced 14.7 feet (6.7 feet into box drain and 8 feet into construction joint drain)
May 9	CJD-3	3 + 28.5	- No water from drain during jetting - Nozzle advanced 16 feet (8 feet into box drain and 8 feet into construction joint drain)
May 9	BH-1	3 + 19.4	- 45 degree borehole intersects box drain at 3 + 28.5 - black water from borehole during jetting
May 9	CJD-4	3 + 58.5	- Nozzle went to bottom of construction joint drain only - Black water from borehole during jetting
May 9	CJD-5	3 + 88.5	- Thick black material came up BH-2 (4 + 30.2) while jetting - All water in gutter runs into this drain - Nozzle advanced 31 feet (21 feet into box drain and 10 feet into construction joint drain)
May 9	CJD-6	4 + 18.5	- Very thick black material came up BH-2 (4 + 30.2) while jetting (2 feet long, 3 inch diameter) - Nozzle advanced 17 feet (2.5 feet into box drain and 14.5 feet into construction joint drain)
May 9	BH-2	4 + 30.2	- Thick black material came up borehole while jetting-similar material to that found while cleaning CJ-5 (3 + 88.5) - After a while, a large amount of fine grained sand came up (looks like calcite with some biotite)

WATER JETTING AND FLUSHING DETAILS (CONT'D)			
Date	CJD/BH	Chainage	Comments
May 9	CJD-7	4 + 48	- Before jetting, hit crunchy material with tape measure at 4.5 feet, then pushed easily to 6 feet - Jetting down to 14.7 feet - After washing, tape measure goes to 12.5 feet where it hit soft material
May 9	CJD-8	4 + 78.5	- Before jetting, hit crunchy material at 3.5 feet with tape measure, then pushed to 4.5 feet - Jetted down to 14.8 feet - Thick black material came up (similar to that obtained from BH-2 while jetting CJD-5) - After 5 minutes, brown water came up
May 9	Drain	4 + 94.5	- One of two original outlet drains from inspection chamber - Advanced nozzle 50 feet with no problems - No immediate affect noticed in tailrace pond
May 9	CJD-9	5 + 08	- Jetted for about 15 minutes with brown material coming out continuously
May 9	Drain	5 + 23.5	- One of two original outlet drains from inspection chamber - Advanced nozzle 40 feet with no problems - No immediate affect noticed in tailrace pond
May 9	CJD-10	5 + 38.8	- Tape measure hits obstruction at 2.5 feet - Jetted for 15 minutes and advanced jet to only 4.9 feet
May 9	CJD-11	5 + 75.9	- Opened with 3 inch diameter borehole - Jetted to about 11 feet - Washed up brown sandy material

WATER JETTING AND FLUSHING DETAILS (CONT'D)			
Date	CJD/BH	Chainage	Comments
May 9	CJD-12	5 + 91	- Opened with 3 inch diameter borehole - Jetted to 1.5 feet, rubble in construction joint drain
May 9	CJD-13	6 + 10.9	- Opened with 3 inch diameter borehole - Jetted to 1.5 feet, rubble in construction joint drain
May 9	CJD-14	6 + 25.9	- Opened with 3 inch diameter borehole - Jetted to 7 feet - Reddish-brown material washed-up and cleared after about 3 minutes
May 9	CJD-15	6 + 45.9	- Opened with 3 inch diameter borehole - Jetted to 4 feet - Reddish-brown material washed up and cleared after about 3 minutes
May 9	CJD-16	6 + 60.9	- Opened with 3 inch diameter borehole - Jetted to 1.5 feet and washed out red-brown material - Advanced to 4 feet where black material washed out - Advanced to 5 feet where brown material washed out and cleared after about 10 minutes
May 9	CJD-17	6 + 90	- Advanced nozzle 33 feet (25 feet into box drain and 8 feet into construction joint drain - Black water washed out

WATER JETTING AND FLUSHING DETAILS (CONT'D)			
Date	CJD/BH	Chainage	Comments
May 10	CJD-8	4 + 78.5	- Tried jetting in CJD-8 again - Advanced nozzle to 14.9 feet after running for 10 minutes (same depth as before) - Brown water with some tar balls came up
May 10	CJD-5	3 + 88.5	- Advanced nozzle to about 40 feet (30 feet into box drain and 10 feet into construction joint drain) - This is 9 feet farther than previous attempt - Water from gutter still running into this drain
May 10	BH-2	4 + 30.2	- Flushed BH-2 with diaphragm pump - Brown water came up CJD-6 (4 + 18.5) when BH-2 was sealed at top - Later water became clear
May 10	CJD-6	4 + 18.5	- Flushed CJD-6 with diaphragm pump - Clear water came up BH-2 (4 + 30.2) but no water came up this construction joint drain
May 10	CJD-5	3 + 88.5	- Flushed CJD-5 with diaphragm pump - No changes at CJD-6 but black water came up BH-2 (4 + 30.2) - BH-2 ran clear after 3 minutes
May 10	BH-1	3 + 19.4	- While jetting, water came up CJD-3 (3 + 28.5) and black material came up CJD-4 (3 + 58.5) - Water was going down CJD-5 (3 + 88.5) - Black material was coming up BH-2 (4 + 30.2) and became cleaner after 5 minutes

WATER JETTING AND FLUSHING DETAILS (CONT'D)			
Date	CJD/BH	Chainage	Comments
May 10	CJD-3	3 + 28.5	- While jetting, black material came up CJD-4 (3 + 58.5) and BH-2 (4 + 30.2) - After 20 minutes, water coming up BH-2 was clean and CJD-4 was fairly clean
May 10	CJD-5	3 + 88.5	- Advanced nozzle about 10 feet - Black material came up and later cleared
May 10	CJD-6	4 + 18.5	- While jetting in CJD-6, black water came up BH-2 (4 + 30.2) - Became cleaner after 3 minutes
May 10	CJD-7	4 + 48	- While jetting a lot of black sand plus some calcite pieces washed up
May 10	CJD-8	4 + 78.5	- While jetting black sandy material came up for about 1 minute
May 10	CJD-17	6 + 90	- Jetted CJD-17 twice in succession
May 14	BH-2	4 + 30.2	- Worked with different nozzles at bottom of hole - Broke through wood into box drain and went 20 feet
May 15	CJD-9	5 + 08	- CJD open and clean to 17.6 feet - Brown water and fine grained sand washed up
May 15	CJD-8	4 + 78.5	- Cleaned to 15.4 feet - Tar balls at bottom of drain - Grey material came up, air came up BH-4 (4 + 58.3)
May 15	CJD-10	5 + 38.8	- Cleaned to 8.1 feet - Brown water came up, black water after 7.7 feet - Tried diaphragm pump, no gain

WATER JETTING AND FLUSHING DETAILS (CONT'D)			
Date	CJD/BH	Chainage	Comments
May 10	CJD-9	5 + 08	- Black water came up while air bubbles came up CJD-8 (4 + 78.5) - Advanced nozzle to 19.3 feet - Pumped water into CJD-8, cloudy water came up CJD-9 - Used jetting and flushing in CJD-9
May 15	CJD-8	4 + 78.5	- Brown water came up CJD-9 (5 + 08) and went down CJD-8 (4 + 78.5) - Water level rises when jetting stopped - Washed up black material while flushing - Jetting and flushing cleared up water with calcite being washed up - Air bubbles came up CJD-7 (4 + 48)
May 15	CJD-6	4 + 18.5	- Black water and wood came up BH-2 (4 + 30.2) while jetting
May 15	BH-2	4 + 30.2	- While jetting no water came out of the hole but the water level was rising in CJD's 2 to 6 (reached gutter level after 10 - 15 minutes) - After jetting stopped, levels dropped in CJD's 2 to 6 - Pushed PVC pipe in 25 feet, then advanced jet 34 feet
May 15	CJD-7	4 + 48	- Black material came up while jetting - Bubbles came out BH-2 (4 + 30.2) and violently from CJD-6 (4 + 18.5) - Flushed then jetted again - Lots of sand came up, ran clear after a few minutes

WATER JETTING AND FLUSHING DETAILS (CONT'D)			
Date	CJD/BH	Chainage	Comments
May 5	CJD-9	5 + 08	- Black water came up CJD-8 (4 + 78.5) while jetting - Air bubbles came up CJD-7 (4 + 48) - White cloudy water came up CJD-8 (4 + 78.5)
May 15	CJD-5	3 + 88.5	- Pushed PVC pipe in 14 feet, then advanced nozzle 42 feet
May 16	BH-3	4 + 94.5	- 53 degree borehole intersects box drain at 5 + 08.5 - Washed for 3 minutes, then clean
May 17	BH-3	4 + 94.5	- Try to cut through wood of box drain by jetting - Wood pieces came up CJD-9 (5 + 08) - No apparent connection to CJD-8 (4 + 78.5)
May 17	CJD-2	3 + 00	- While flushing, black water came out of BH-2 (4 + 30.2) - Plugged up BH-2, flushed for 35 minutes, then pulled plug - Water in CJD's 2, 4, 5 and 6 dropped immediately - CJD-3 still flowed after 41 minutes
May 17	CJD-4	3 + 58.5	- Appears to be a blockage between CJD-4 (3 + 58.5) and CJD-5 (3 + 88.5) - Flushed CJD-4, black water came up and then cleared - Larger pieces continued to come up for some time

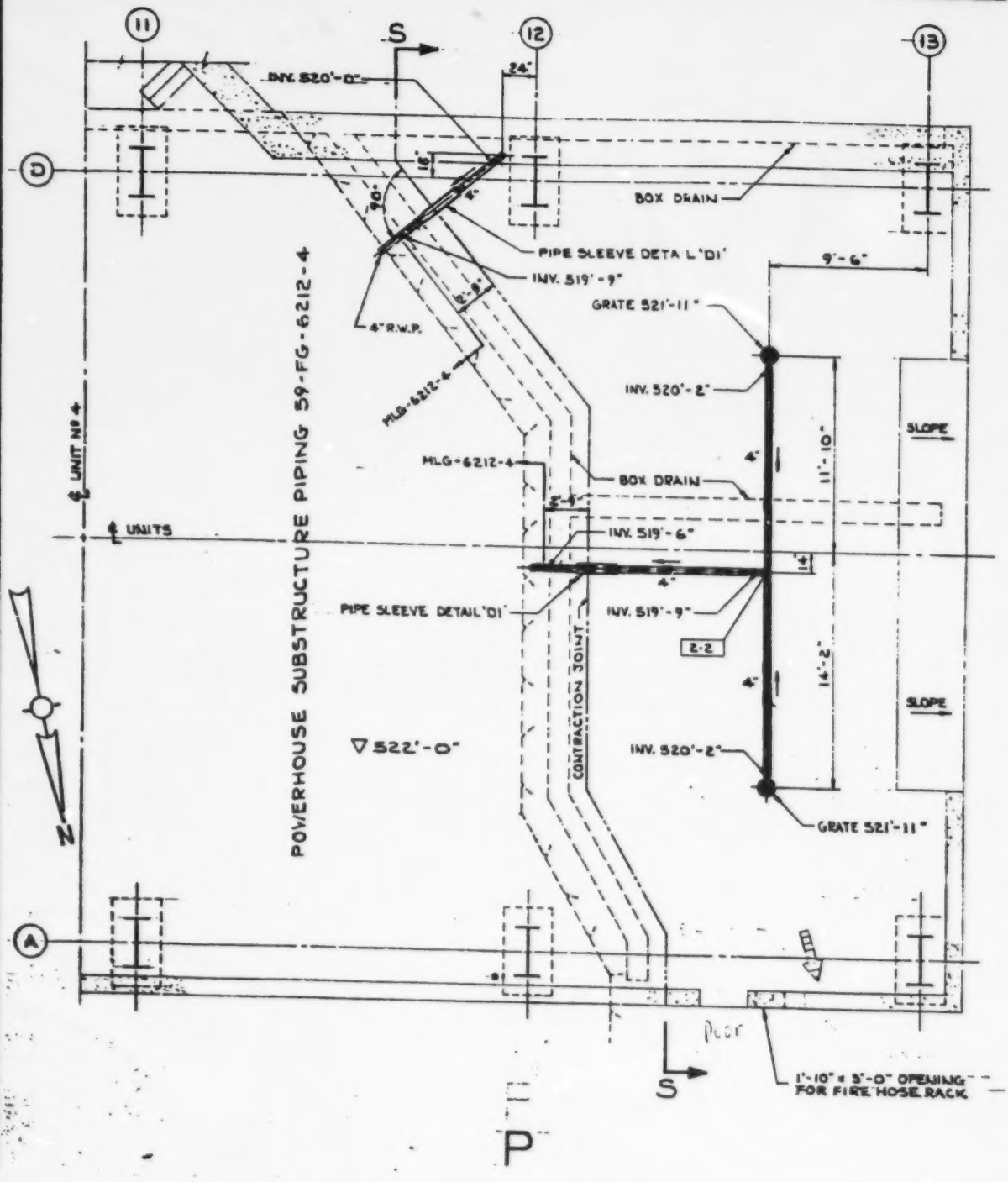
WATER JETTING AND FLUSHING DETAILS (CONT'D)			
Date	CJD/BH	Chainage	Comments
May 18	BH-4	4 + 58.3	- Drilled BH-4 to 17.5 feet - Brought up 3 inches of wood - Drilled hole to 17.9 feet on May 27 - water came up CJD-7 (4 + 48) - Jetted hole, water came up CJD's 8 (4 + 78.5) and 9 (5 + 08) and BH-3 (4 + 94.5) - Advanced jet to 20.5 feet
May 24	BH-4	4 + 58.3	- Put borehole camera in borehole at about 18 feet and obtained a good view of the box drain
May 24	BH-4 BH-3 CJD-4 CJD-5 CJD-3	4 + 58.3 4 + 94.5 3 + 58.5 3 + 88.5 3 + 28.5	- Electric snake to 23 feet - Electric snake to 23 feet - Electric snake to 45 feet - Electric snake to 12 feet north - Electric snake to 26 feet south
May 24	BH-2	4 + 30.2	- Put plug in BH-2 (4 + 30.2) - Water spilling out of CJD's 4, 5 and 6
May 24	CJD-10	5 + 38.8	- Construction joint obstructed at 8 feet before it was open by jetting - Water came up BH-3 (4 + 99.5) and BH-4 (4 + 58.3)
May 24	BH-4	4 + 58.3	- Used Roto-screamer to cut wood very successfully - Examined borehole with borehole camera
May 24	CJD-10	5 + 38.8	- Found some evidence of grout in this hole - A piece of grout from BH-4 (4 + 58.3) was sampled

WATER JETTING AND FLUSHING DETAILS (CONT'D)			
Date	CJD/BH	Chainage	Comments
May 28	CJD-7	4 + 48	- Jetted down to 15 feet - Fine grained sand, some grout pieces, some wood and some tar balls came up BH-4 (4 + 58.3)
May 28	BH-4	4 + 58.3	- Used 20 foot long pvc pipe to get nozzle around the corner in the box drain - Advanced nozzle 27.3 feet (9 feet into box drain) - 5 pails of gutter material were removed (mostly drill cuttings)
May 29	CJD-10	3 + 38.8	- While flushing, water came up CJD's 9 (5 + 08) and 8 (4 + 78.5) and BH-3 (4 + 94.5) and BH-4 (4 + 58.3)
May 29	CJD-9	5 + 08	- While flushing, water came up the same locations as for the CJD-10 flushing - Pieces (3/4 inch and smaller washed up BH-3 (4 + 94.5)
May 29	CJD-10	3 + 38.8	- While flushing, more material was washed up BH-3 (4 + 94.50)
May 29	CJD-9	5 + 08	- While flushing, less material than the first time was washed up
May 29	BH-3	4 + 94.5	- While flushing, black water and some tar balls came up
May 29	CJD-8	4 + 78.5	- While flushing, a lot of granular material came up CJD-8 - Water came up BH-3 (4 + 94.5) and BH-4 (4 + 58.3)

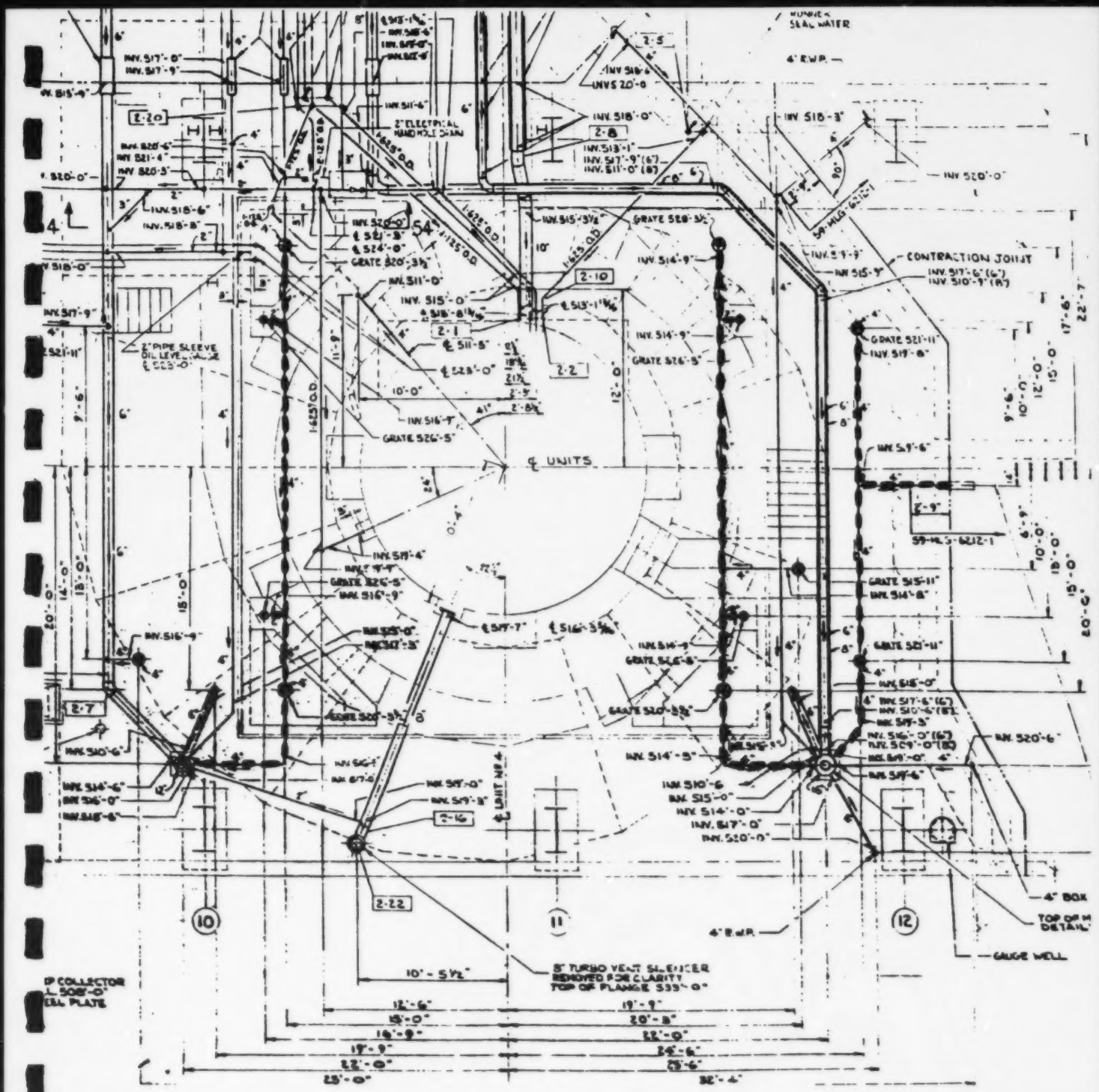
WATER JETTING AND FLUSHING DETAILS (CONT'D)			
Date	CJD/BH	Chainage	Comments
May 29	CJD-7	4 + 48	- While flushing, a lot of tar, some wood and fine grained material came up BH-4 (4 + 58.3)
May 29	BH-4	4 + 58.3	- While flushing, a lot of granular material came up CJD-7 (4 + 48) - Much of the material looks like green grout
May 29	CJD-6	4 + 18.5	- Before flushing, took out packer from BH-2 (4 + 30.2) which had been in since May 28 (noon) and read 1.5 psi - Water came up BH-2, but there was little debris in it
May 29	CJD-5	3 + 88.3	- During flushing, fine grained material and the odd tar ball came up BH-2 (4 + 30.2) - All water went down CJD-5 (3 + 88.3) and CJD-6 (4 + 18.5)
May 29	CJD-4	3 + 58.5	- During flushing water exited at the source

Note: All construction joint drains and boreholes listed above were flushed again in reverse order. They were all reported to be clean. Some pieces of material came up BH-3 (4 + 94.5) when flushing was undertaken in CJD-9 (5 + 08). A total of about one cubic yard of material was removed from the drains.

APPENDIX C:
DRAIN LOCATIONS AT BARRETT CHUTE GS AND MOUNTAIN CHUTE GS POWERHOUSES



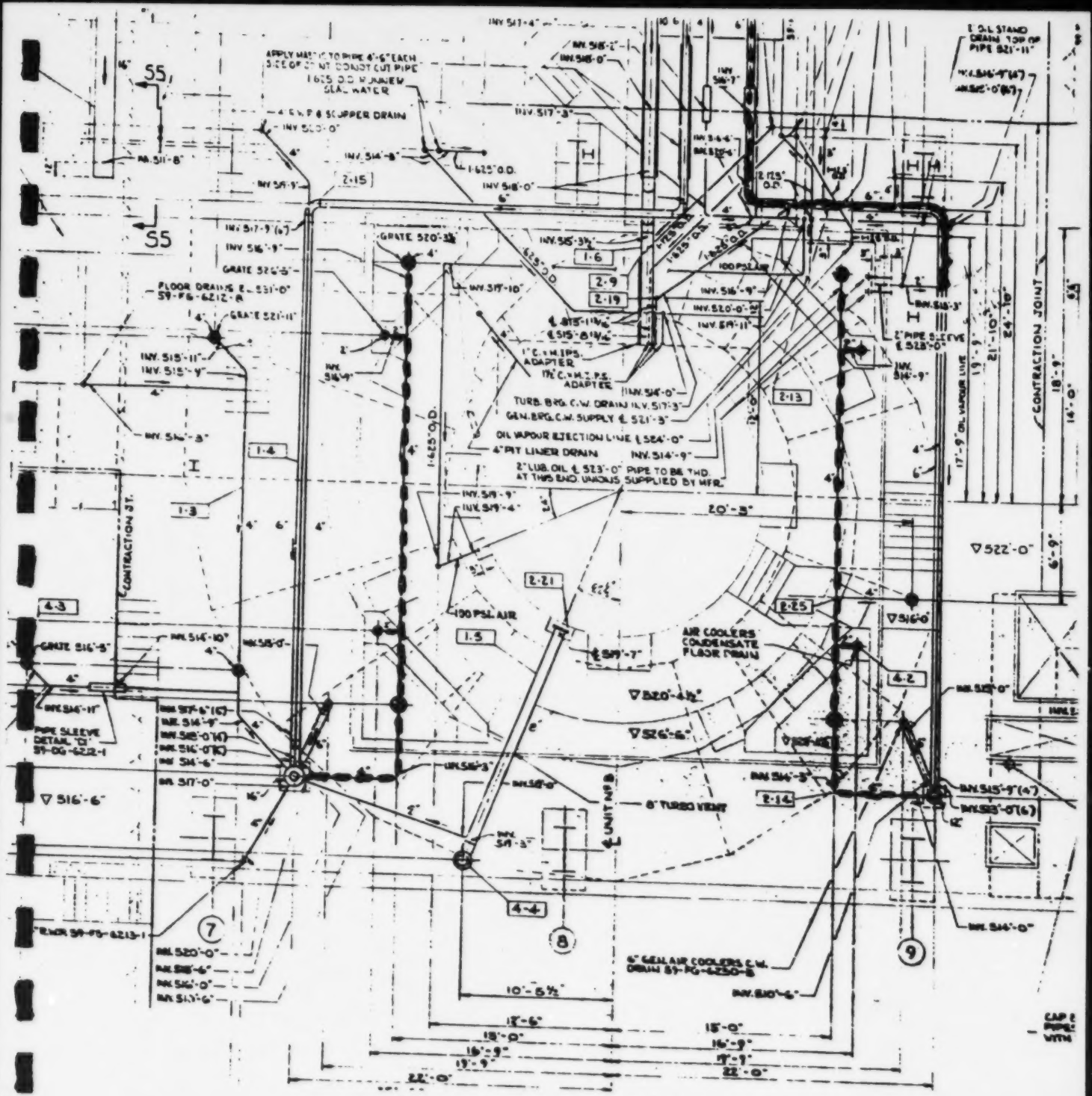
Plan A: Reference Drawing No. 59-DG-6212-1
Barrett Chute GS
Unloading Bay - Substructure Piping



Plan B: Reference Drawing No. 59-FG-6212-4

Barrett Chute GS

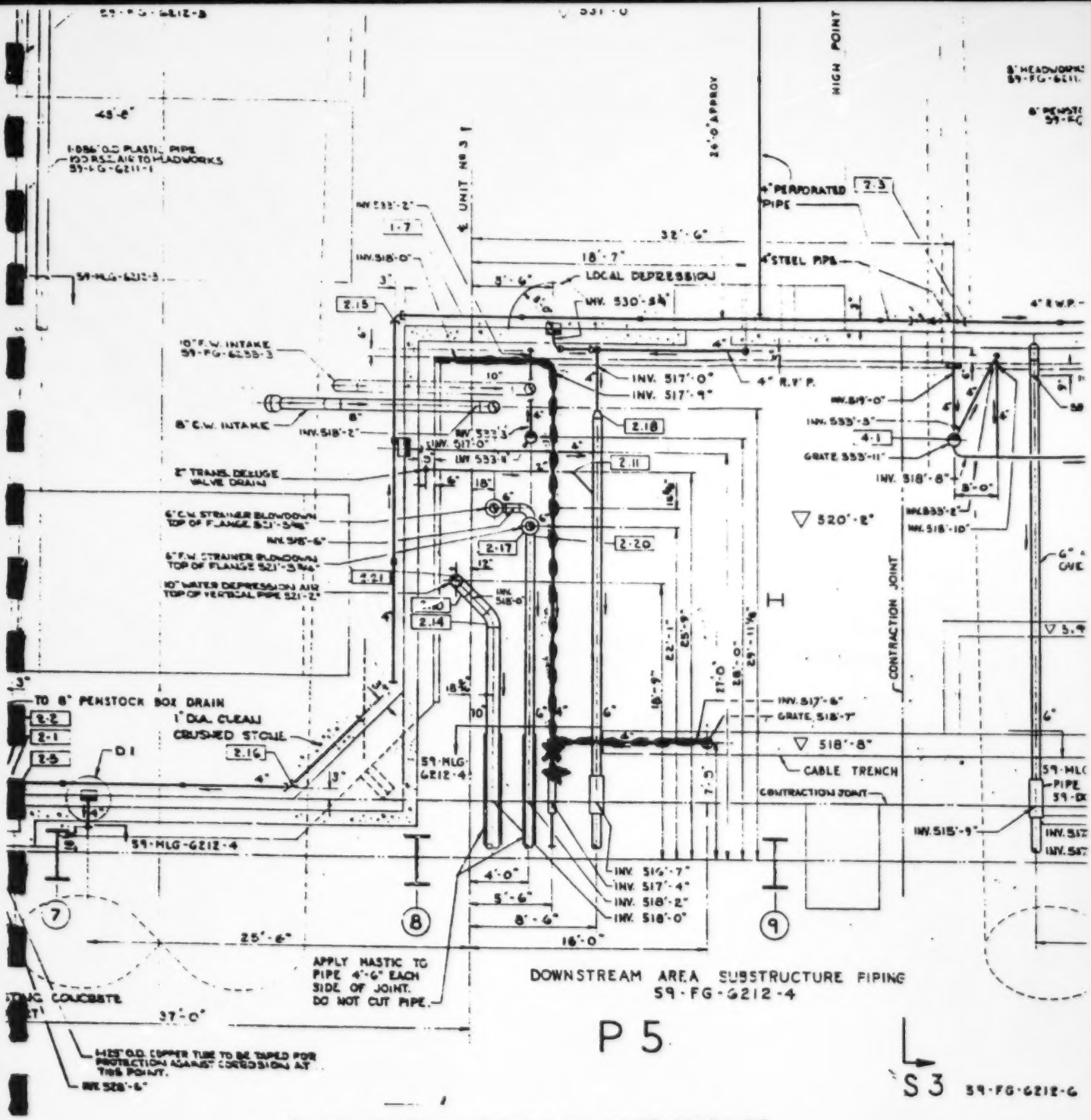
Station Drainage System Plan At Elev 522 - Substructure Piping



Plan C: Reference Drawing No. 59-FG-6212-4

Barrett Chute GS

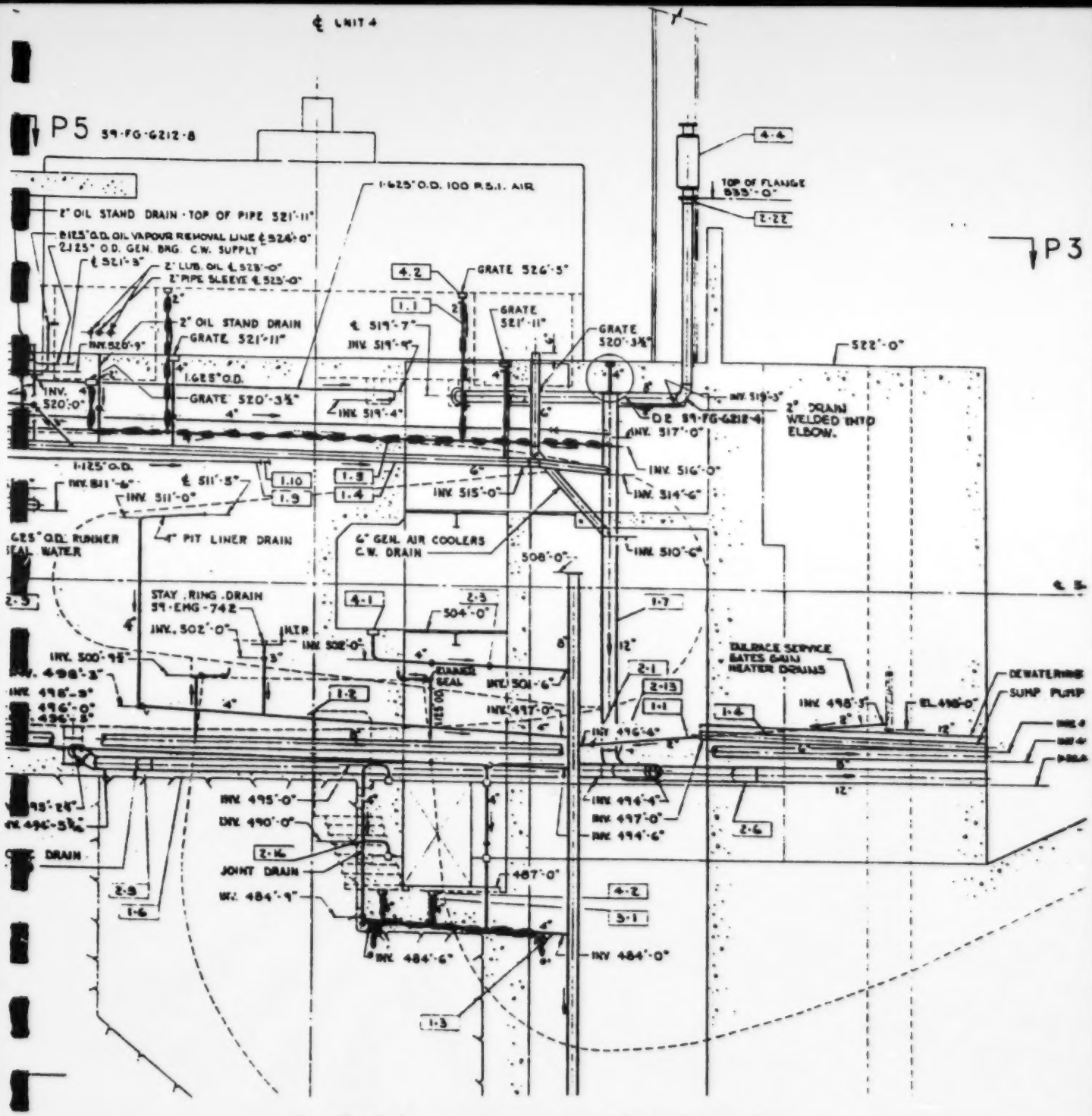
Station Drainage System Plan At Elev 522 - Substructure Piping



Plan D: Reference Drawing No. 59-FG-6212-8 RS

Barrett Chute GS

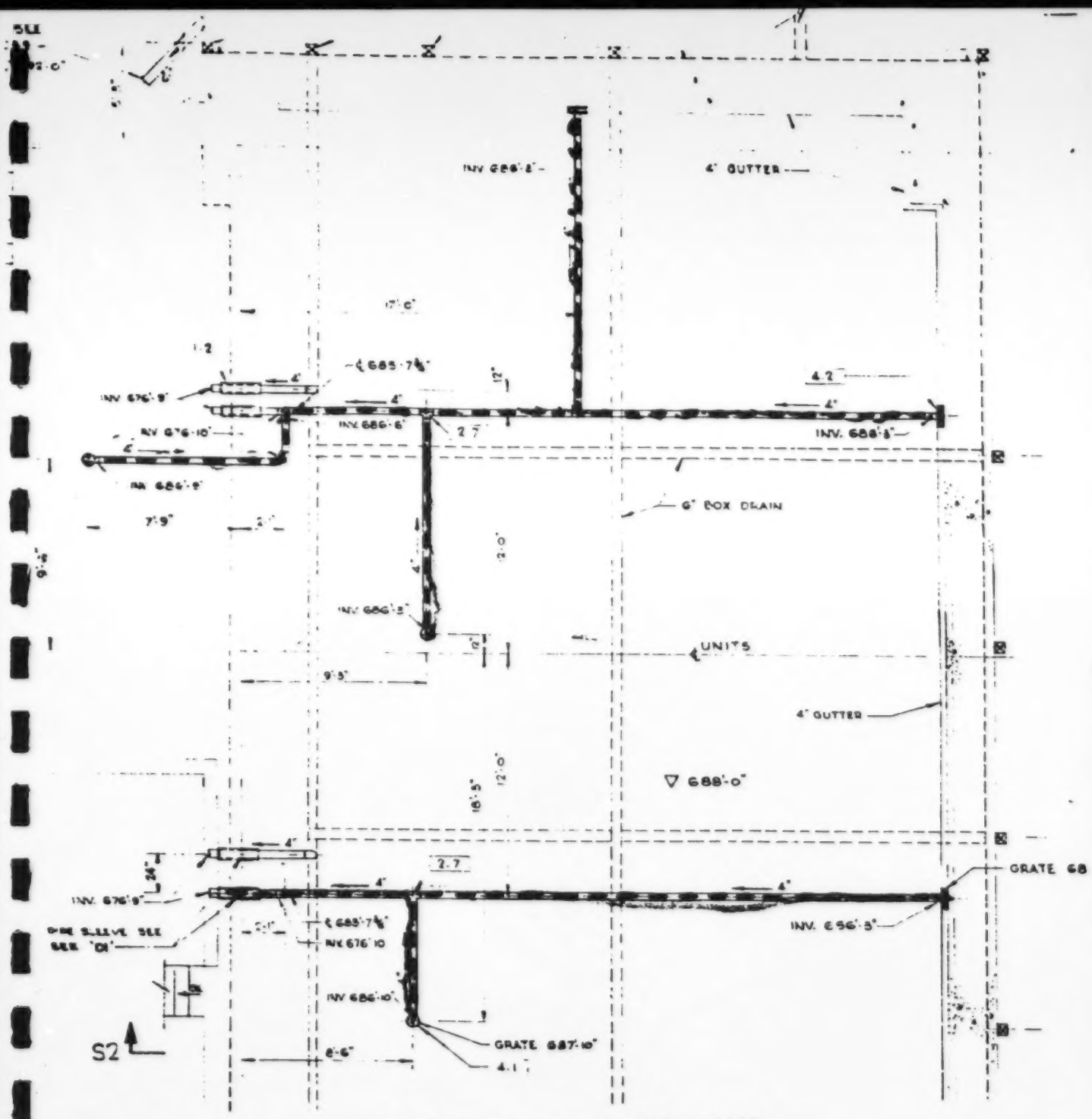
Station Drainage System Upstream Area - Substructure Piping



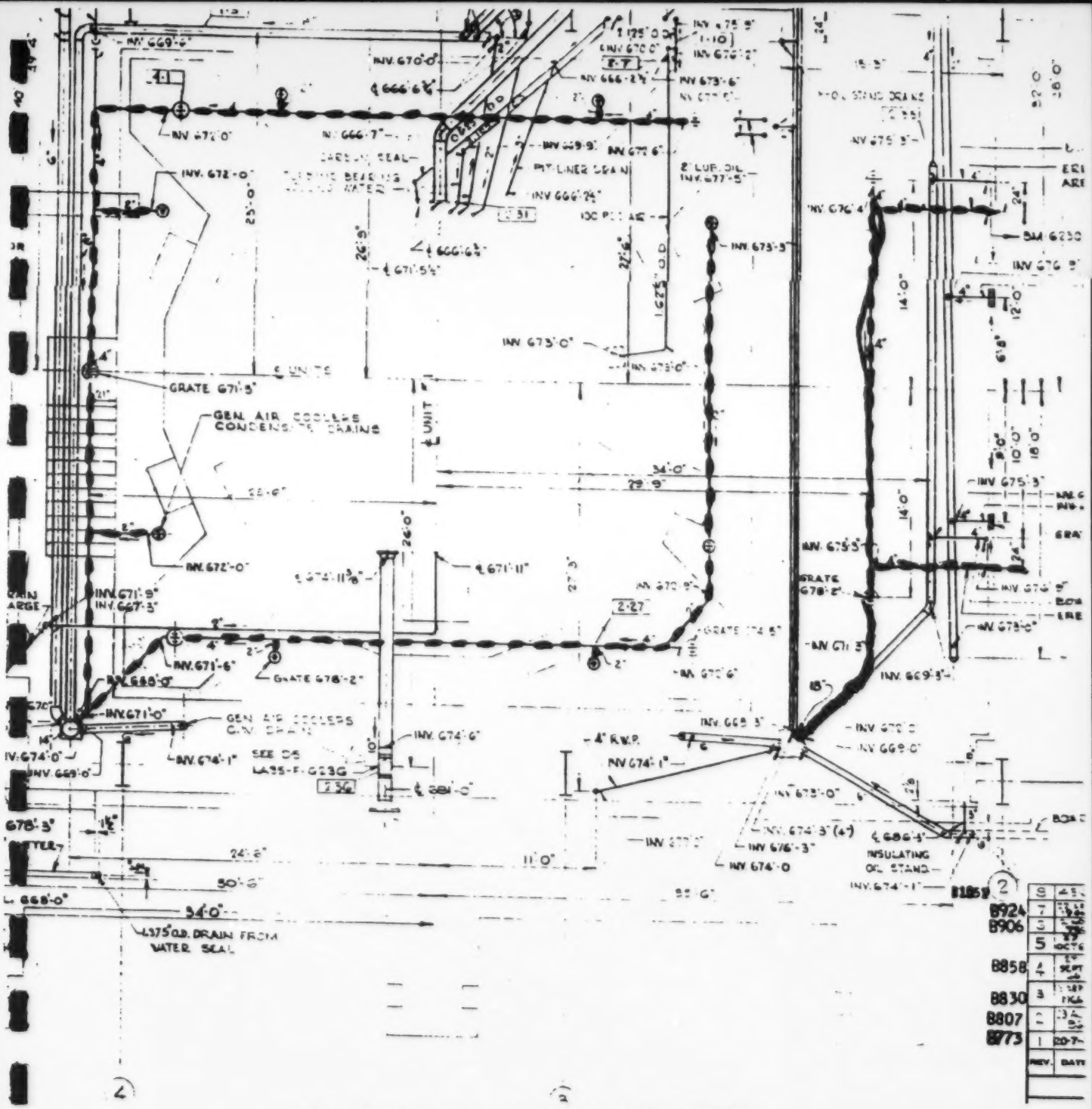
Plan E: Reference Drawing No. 59-FG-6212-6 RS

Barrett Chute GS

Station Drainage System Section 53 - Substructure Piping



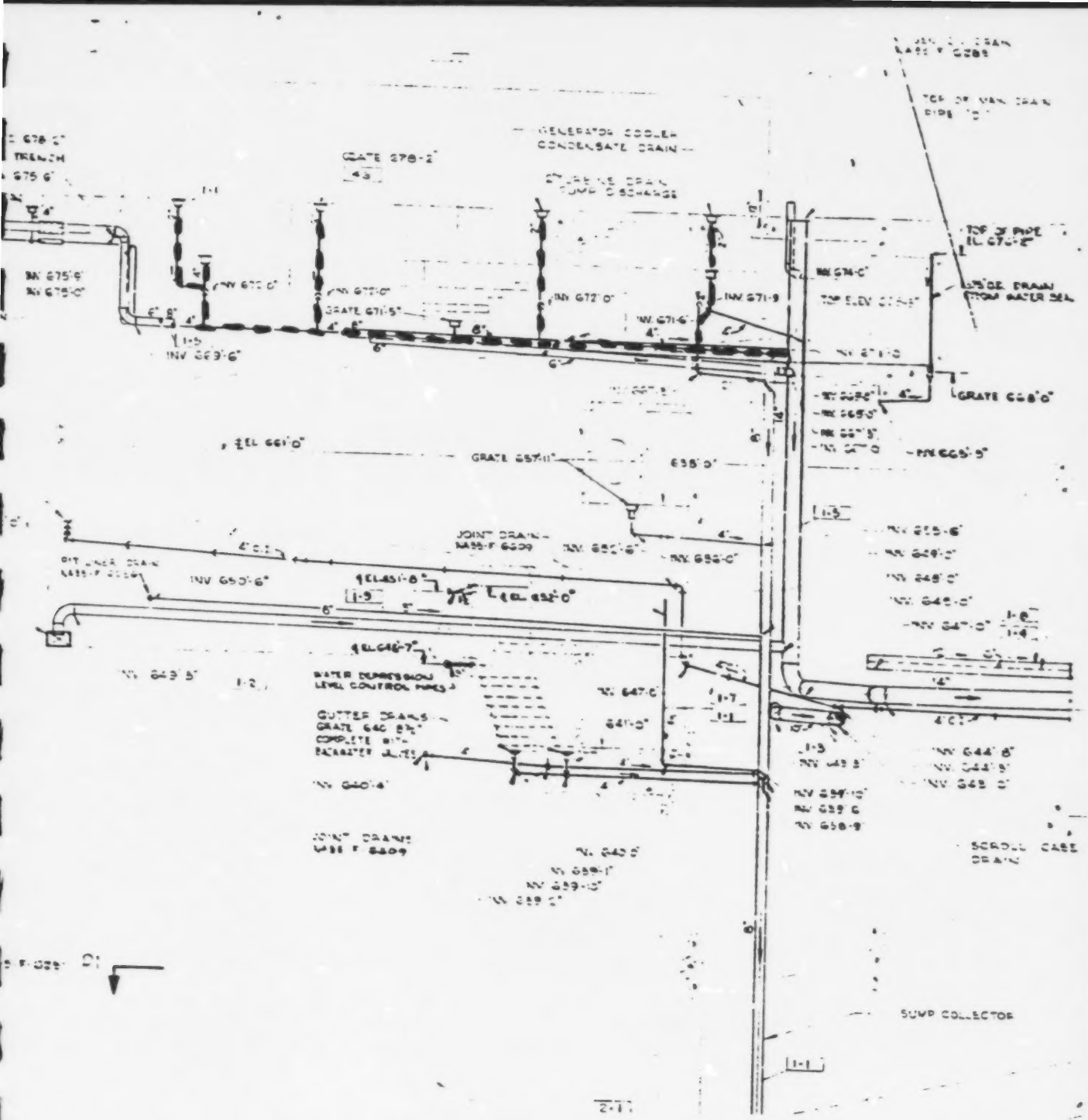
Plan F: Reference Drawing No. NA35-F-6230
Mountain Chute GS
Erection Bay - Substructure Piping



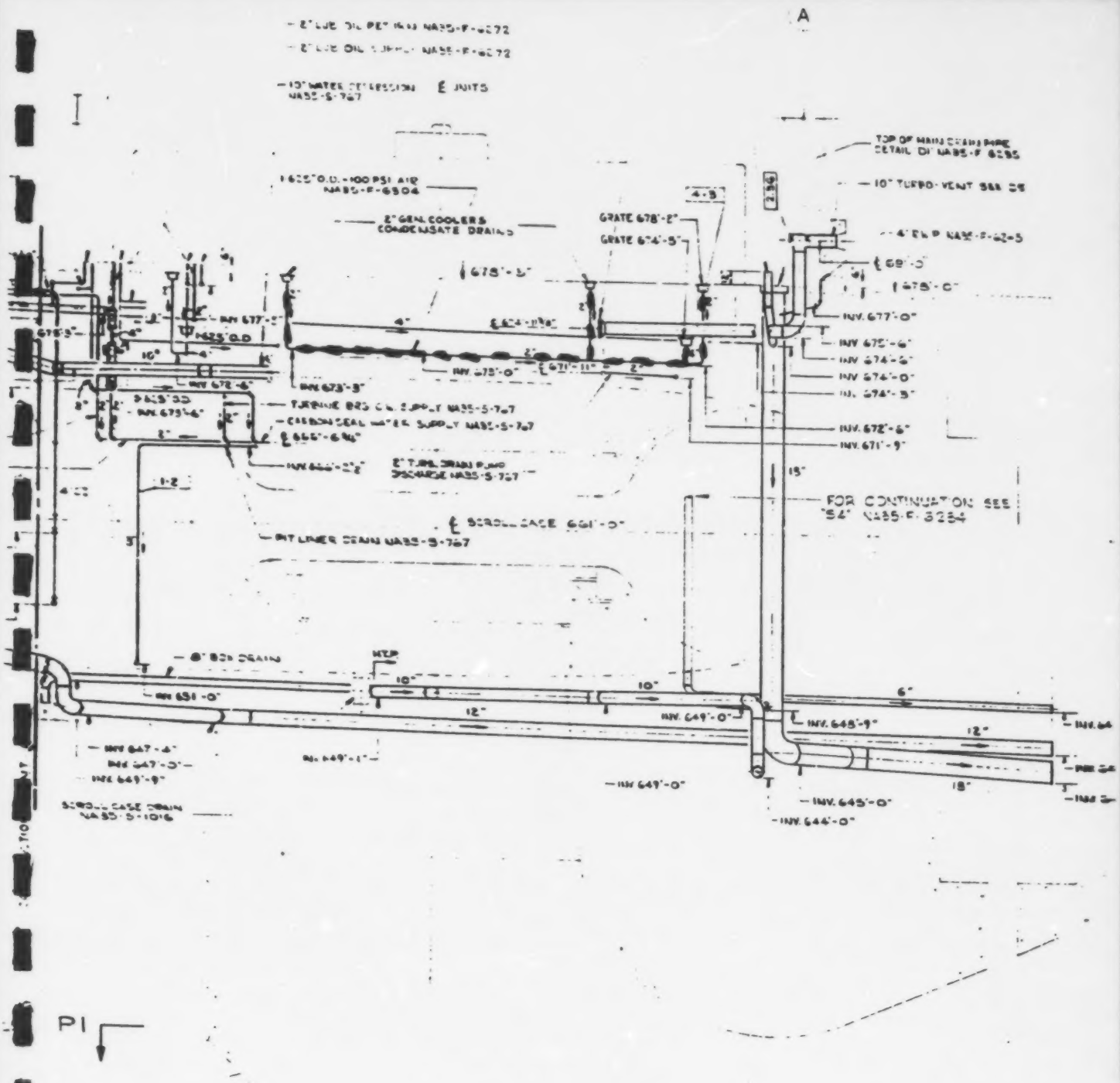
Plan G: Reference Drawing No. NA35-F-6233

Mountain Chute GS

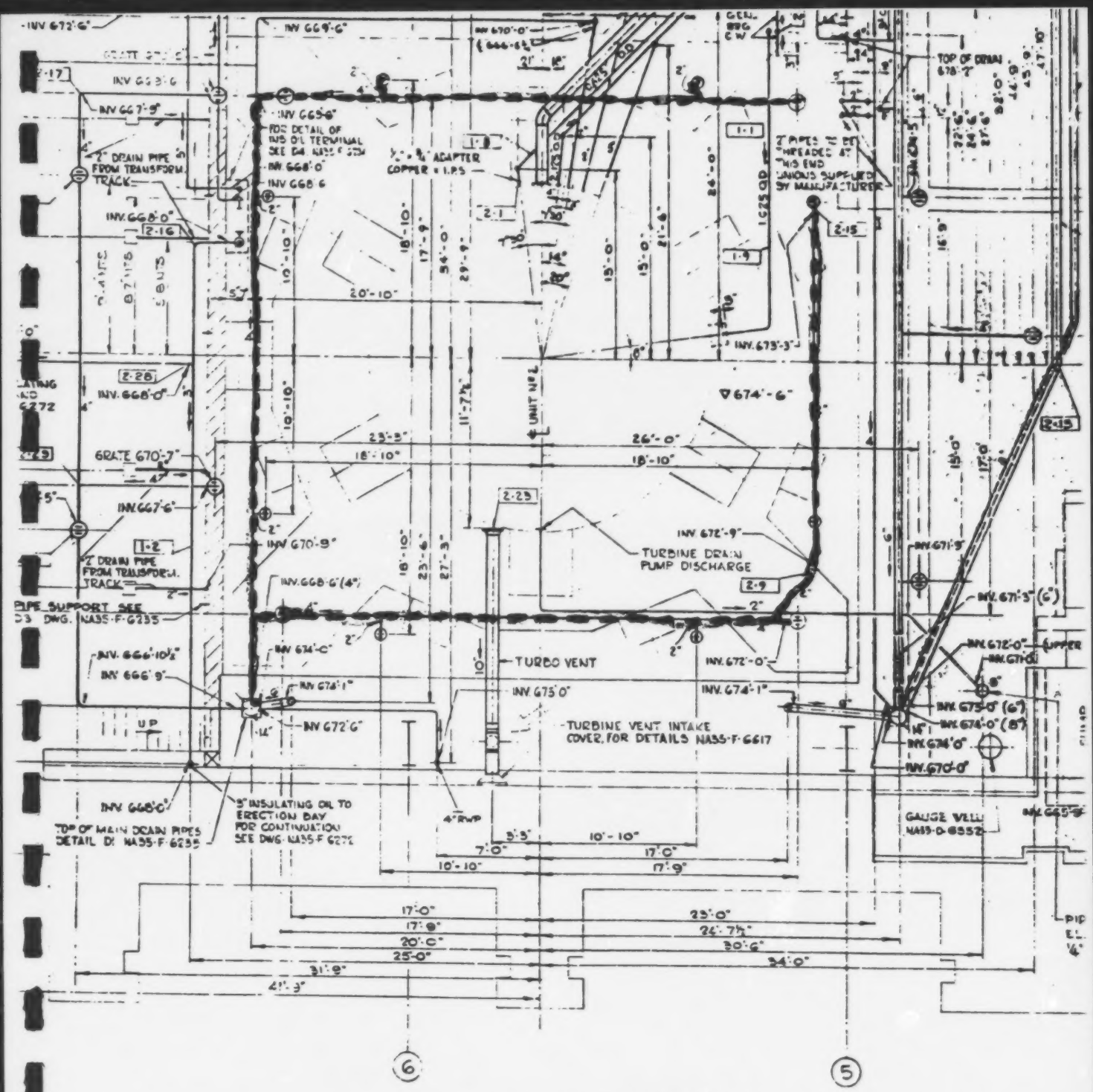
Powerhouse Plan At Elev 678' - 10 1/2" & 678' - 3" Substructure Piping



Plan H: Reference Drawing No. NA35-F-6235
Mountain Chute GS
Powerhouse Section 52 - Substructure Piping



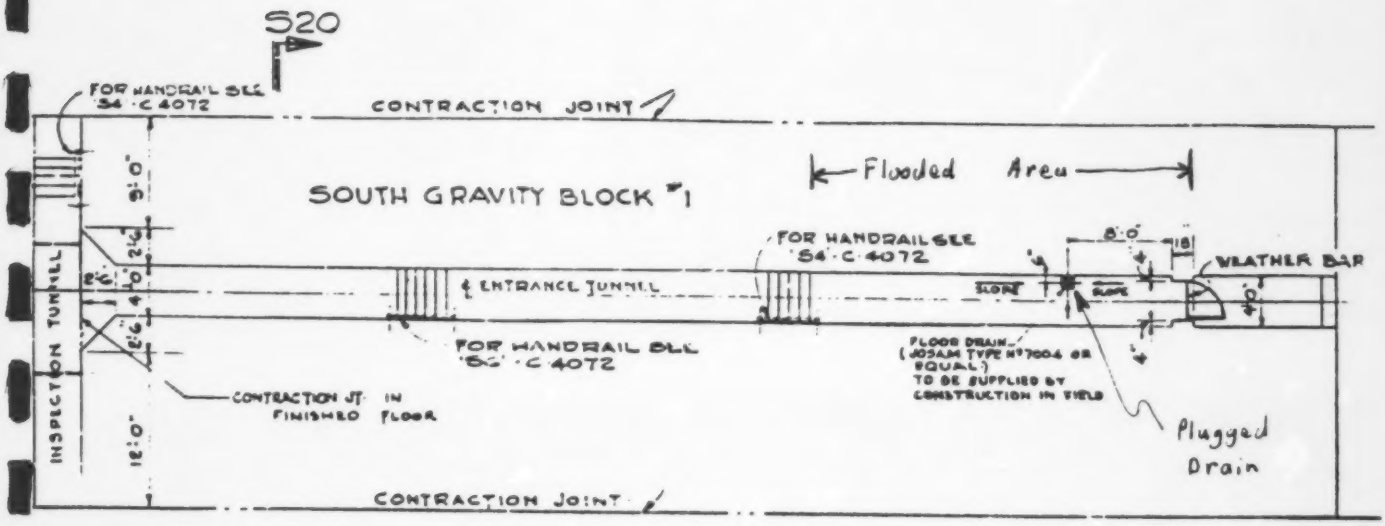
Plan I: Reference Drawing No. NA35-F-6236
Mountain Chute GS
Powerhouse Section S3 - Substructure Piping



Plan J: Reference Drawing No. NA35-F-6233

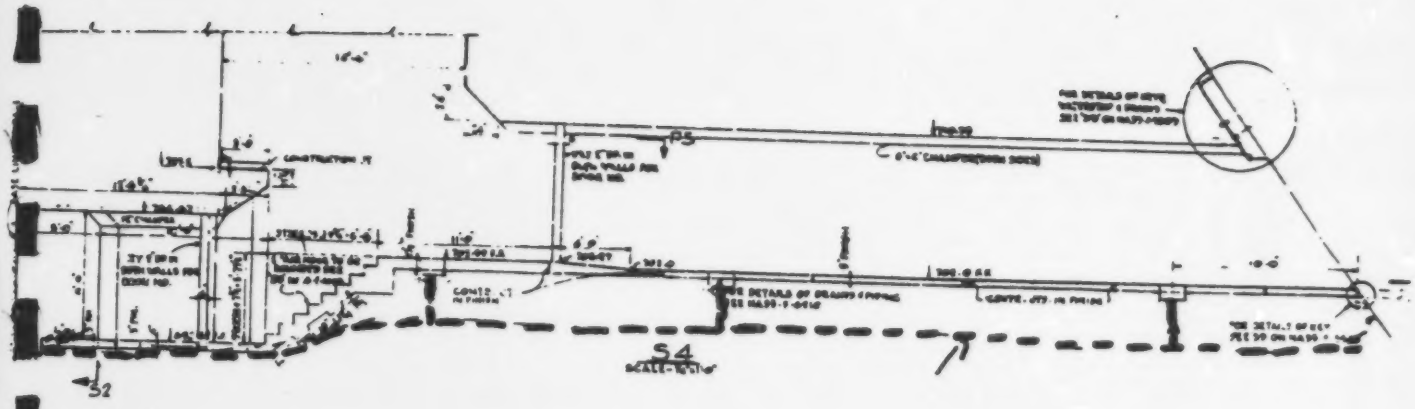
Mountain Chute GS

Powerhouse Plan At Elev 678′ - 10 1/2" & 678′ 3" - Substructure Piping



P14

Plan K: Reference Drawing No. NA35-F-4040
Mountain Chute GS Main Dam
Gravity Sections - Inspection Tunnel Entrance - Concrete & Construction Joints



Plan L: Reference Drawing No. NA35-F-5504
Mountain Chute GS
Headworks - Units 1 & 2 Inspection Tunnel - Concrete & Construction Joints & Drains